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ABSTRACT

The effects of classroom assessment environment (CAE) variables on yearly achievement in mathematics and science in grades 7 through 12 were studied through the Longitudinal Study of American Youth (LSAY), using cohorts of approximately 3,000 students each in the 7th and 10th grades who were followed for 4 years. While the LSAY did not include all CAE variables of theoretical interest, it did include reasonable approximations of many. The direction of CAE effects was consistent for some variables and inconsistent for others. Percent of homework corrected and returned to students had a negative effect whenever it appeared. Hours of homework assigned and percent of students completing homework on time had positive effects when they appeared. Percent of class time used for testing and evaluation had significant effects only on math achievement (two negative and one positive). Frequency of oral reports had a significant negative effect for science, while frequency of written reports had mixed effects. Results do show some CAE effects, and CAE theory does explain some, but not all, of these effects. Results support the beginnings of a theory explaining the relationship between classroom assessment and student achievement. Six tables and two figures present study data. (Contains 14 references.) (SLD)

EFFECTS OF THE CLASSROOM ASSESSMENT ENVIRONMENT ON ACHIEVEMENT IN MATHEMATICS AND SCIENCE

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Stiggins and Conklin (1992) defined the classroom assessment environment as an overarching construction for how a teacher uses classroom assessment, including the part it plays in classroom instruction and student learning. This broad construct subsumes both objective indicators (e.g., frequency of testing), and subjective indicators (e.g., quality of tests). The classroom assessment environment is not formed only by tests, but encompasses all the exercises and opportunities teachers arrange to observe and judge students and, sometimes, for students to assess each other. Stiggins and Conklin (1992) developed the Classroom Assessment Environment Profile to measure this construct. Its dimensions include assessment purposes, assessment methodologies, criteria for selection, quality of assessments, feedback, the teacher as assessor, the teacher's perception of students, and the assessment-policy environment.

One key to effective use of classroom assessment is the quality and usefulness of feedback to students (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991). Students' perceptions of both the quality of the feedback and their own competence as learners depend in part on the feedback providing clear information students can use (Brookhart, 1994; Ryan, Connell, & Deci, 1985). Student perceptions are important mediators of classroom assessment environment effects. Student perceptions of the quality of the class, its importance and utility, and how difficult it was for them were included as variables in this study. The theoretical argument for how these perceptions function to affect the way students interpret and use classroom assessment information is made in Brookhart (1995, available from author).

How important is the classroom assessment environment to achievement? While it should be a major factor within classes (Stiggins, 1994), is it major when compared with known influences on math and science achievement like socioeconomic status (Oakes, 1990; Walberg, 1991), gender (Tittle, 1986), or general academic aptitude? Understanding the effect of the classroom assessment environment, especially if and when it functions beyond powerful known influences on achievement, will be important for both developing theory and informing practice.

The general research question for the study was:

What are the effects of classroom assessment environment variables on yearly achievement in mathematics and science in grades 7 through 12?

Specific questions implied by this general one included: How can these effects be modeled? What is the nature of the effects (direct, indirect, suppressive, etc.)?

Method

Data source. The Longitudinal Study of American Youth (LSAY) used a national probability sample, stratified by geographic region and degree of urban development, of approximately 3000 students each in the 7th and 10th grades in the U.S. public schools in the fall of 1987. Students were followed for four years, until 1991. This study used data from both cohorts. Data were obtained from the LSAY project office, on computer tape. Codebooks provided information about the sample, instruments, and variables (Miller, Hoffer, Suchner, Brown, & Nelson, 1992a,b).

Instrumentation. The LSAY surveys and tests did not include all Classroom Assessment Environment variables of theoretical interest. However, this study was designed because in its various surveys and tests, the LSAY included reasonable approximations to many of the variables of interest, for a nationally representative sample over four years of time. This afforded the opportunity to explore the effects of classroom assessment environment on achievement. Table 1 lists all variables, and the scales used to measure them, for this study.

Outcomes of interest included mathematics and science achievement, each measured yearly on a 100-point scale developed from a 3-parameter IRT model. Background variables included gender (coded 0-1), SES (a composite variable of parental education, parental occupational status, and a household possession index), and general academic ability. The academic ability variable was operationally defined as scores on a 15-item reading comprehension test (α=.86) that has been found to function as a general academic measure in other LSAY analyses (Miller, 1992).

For measures of the classroom assessment environment, variables from student and teacher questionnaires were inspected. The following variables were selected as the best indicators of classroom assessment environment available in the LSAY data because they measured either the frequency or quality of opportunities teachers provided for students to do work that would be judged or students' reactions to these opportunities. These classroom assessment environment variables were from teacher reports: percent of class time allotted to testing/ evaluation; frequency (scale 1-5, every day to very rarely) of written reports on experiments (science only), oral reports, design/conduct own science projects (science only), written reports on outside readings, and (for some years) explain reasoning to arrive at answer; and homework hours per week assigned, percent students completing homework on time, and percent homework collected and returned. These variables were from student reports: liking the subject matter, teacher clarity, challenge, perceived career utility, difficulty, and homework. Students were matched with the teacher variables from their respective mathematics or science classroom teachers for each year. The student variables provided measures of student perceptions of and reactions to the classroom assessment environment, hypothesized to be important mediators between the environment and performance (Pintrich & Schrauben, 1992; Schunk, 1994).

Analyses. Likert scales were reversed so that the more positive student responses (e.g., challenges a lot) and the teacher responses indicating more frequent use of a method (e.g., every day) were at the high end of the scales. All analyses used sampling weights. Path analysis was the major analytical tool, and the student was the unit of analysis. Most classes in the LSAY data reconfigured each year; path analysis maintained the longitudinal design for students. Four separate path analyses were done, in mathematics and science, respectively, for each cohort of students. Figures 1 and 2 present the original models tested. They differ in that Cohort 1 had three years (10th through 12th grades) and Cohort 2 had four years (7th through 10th grades) of data.

Stepwise regression was used to fit these recursive models. Using regression to fit models for successive years allowed for using the maximum number of students in each year, and each year's analysis used sampling weights for the respective years. Thus these models reflect the maximum available information. However, fitting the recursive model by means of separate regressions did not permit the calculation of an overall fit statistic for the entire model. It was reasoned that the inclusion of information from hundreds more subjects made this cost worthwhile. Table 2 presents weighted sample sizes and adjusted R^2 values for each of the stepwise regressions that contributed to the fitted models. Note that sample size varies widely because of availability of complete data.

Results

Tables 3 through 6 present the effects for the fitted models, which report the path coefficients from the best model identified for each of the achievement measures. Variables tested (see Table 1) but not listed in Tables 3 through 6 did not have statistically significant effects and were dropped from the model. The effects that were identified must be considered tentative findings because of the missing data problem for some of the component analyses. The missing data for high school seniors may be explained by the number of students who finish math and science requirements before their senior year and do not take additional classes in these subjects. The small numbers in some years for Cohort 2, especially in 7th grade science, present a problem for generalization.

Math. The largest effects on ultimate math achievement, for both the junior high and high school cohorts, were the effects of prior achievement and general reading ability (Tables 3 and 4). SES and gender had greater effects on the achievement of the high school cohort than the junior high school cohort. The effect of gender was in favor of male students.

Some of the classroom assessment environment (CAE) variables had statistically significant effects, too. For Cohort 1, the percent of students completing homework on time in 10th grade math class and the hours of homework assigned per week in both 10th and 12th grade math classes are each roughly a quarter of the size of the effect of reading ability. The percent of time devoted to testing and evaluation in 10th grade math class and the percent of homework corrected and returned to students had negative effects on achievement.

For Cohort 2, the strongest positive CAE effects were for perceived teacher clarity and percent of students completing homework on time in 10th grade math class, percent completing homework on time in 7th grade math class, and perceived difficulty of 7th grade math class. Percent of homework corrected and returned to students in 7th, 8th, and 9th grades had negative effects on achievement. The percent of class time used for testing and evaluation had a negative valence in 8th grade, as for 10th grade in Cohort 1, but a positive valence in 7th grade. How often written reports were assigned in 9th grade math class had a negative effect on achievement. In general, for both cohorts, the homework variables were the CAE variables that remained in the models.

Science. The largest effects on ultimate science achievement for both cohorts were the effects of prior science achievement and general reading ability (Tables 5 and 6). For both cohorts, there was a gender effect on achievement, favoring males. This effect was fairly large for the high school cohort.

Some CAE variables also had statistically significant effects. For Cohort 1, positive effects included percent completing homework on time in 10th grade science class, hours of homework assigned per week in 10th grade, how often science projects were assigned in 10th grade, and perceived difficulty of 10th grade science class. Negative effects were found for how often oral reports were assigned in 10th grade science class and the percent of homework corrected and returned to students in 11th grade science class.

For Cohort 2, the strongest CAE effect was from how often science projects were assigned in 7th grade science class. Perceived clarity of the 7th grade textbook and how often written reports were assigned in 8th grade also had positive effects. Negative effects were found for how often written reports were assigned in 7th grade science class, how often oral reports were assigned in 8th grade, and how often students were called upon to explain their reasoning in 9th grade science class.

Comparing math and science. There are some similarities and some differences among the math and science models. The effects of prior achievement on subsequent achievement were strong for both math and science. So was the effect of reading ability, which was even stronger for Cohort 2 (grades 7-10) than for Cohort 1 (grades 10-12). There were SES effects for mathematics but not for science achievement. Gender effects were stronger for science than for math, and they were stronger for the older cohort than for the younger (-.28 *cf* -.12 for science; -.13 *cf* .00 for math).

Some patterns are apparent for the CAE effects overall. Homework variables were most pervasive for mathematics achievement. Homework variables and the frequency of various types of assessment opportunities (oral reports, science projects) shared in the overall effect on achievement for science in high school. Frequency of various types of assessment opportunities (oral reports, written reports, sciences projects) were significant for science achievement in Cohort 2.

The direction of the CAE effects is consistent for some variables and inconsistent for others. Percent of homework corrected and returned to students had a negative effect whenever it appeared. Hours of homework assigned and percent of students in the class completing homework on time had positive effects whenever they appeared. Percent of class time used for testing and evaluation, which had a significant effect only on math achievement, had mixed valences (2 negative and 1 positive). Frequency of oral reports, which had a significant effect only in science, had negative values. Frequency of written reports had mixed effects (3 negative and 1 positive). Frequency of science projects had a positive effect both times it appeared, once each for both the older and younger cohorts of students.

Differences noted among the math and science models may reflect real differences in effects on math and science achievement. However, to the extent that findings were artifacts of reduction in sample size for some components of the analyses, apparent differences between effects on math and science achievement may be spurious.

Discussion

The following interpretations may be made of the results for the students whose achievement was analyzed in this study. Sample size problems limit the generalizability of results and preclude claims of national representativeness.

Does this study support the importance of the classroom assessment environment for achievement? Was it amazing that there were CAE effects that were not washed out by the powerful effects of student background and prior achievement? Or was it disappointing that the effects weren't larger?

The results do show that there were some CAE effects (Stiggins & Conklin, 1992) beyond student background and prior achievement. And CAE theory does explain some--but not all--of these effects. Most of the CAE variables tested that remained in the models (*i.e.*, that had signficiant effects) were teacher report variables. This suggests that classroom controllables are important and that an "environment" can indeed be created.

The importance of homework variables to mathematics achievement is probably best explained by learning theory and the importance of practice to mastery, especially in solving the kind of formal problems posed in math. But it is in the classroom assessment environment that this student practice with the material is mediated (assigned, explained, feedback given, etc.), so the classroom assessment environment has a role to play. The surprising finding was the negative effect on achievement of percent of homework corrected and returned to students. This appears to be counter to the results that a theory of the classroom assessment environment would predict, namely, that homework corrected and returned would function as informative feedback and should affect achievement positively. The theory could be wrong. But since it is counter-intuitive as well as counter to the theory to suggest that informative feedback is bad for achievement, consider some other possible explanations. Perhaps many of the classes where lots of homework was corrected and returned to students were classes in which exercises were corrected in class, round robin fashion, at the beginning of the next day, perhaps even in "switch with your neighbor" fashion. Or perhaps many of the classes where a large amount of homework was corrected and returned used student graders (not active self-assessors, but answer-checking clerical helpers). The negative effects of these practices on the classroom environment, especially in making students' mistakes public, could be expected to ruin the informative effects of the feedback. Classroom assessment environment theory would explain that, since student perceptions of their own competence and emotional factors (for example, embarrassment) would cause feedback from such corrected homework to have a "controlling" function, not an informational one (Brookhart, 1995; Ryan, Connell, & Deci, 1985).

The importance of the frequency of oral reports, written reports, and science projects on science achievement is also interesting for classroom assessment environment theory. The formats used for classroom assessments are an important part of the classroom assessment environment (Stiggins & Conklin, 1992). The effect of these format variables for science and not mathematics is probably a function of subject matter. Science lends itself to oral and written reports and to projects; math lends itself to practice problems, and therefore to homework.

Format effects were not all positive. Oral reports had negative effects on achievement. The simplest explanation for this may come from learning theory and time on task. Oral reports take a great deal of class time, during which one student may be thinking hard while other students are much less engaged. Science projects had positive effects. This makes sense from several theoretical points of view: active learning, student construction, curiosity and motivation, self-evaluation. Written reports had mixed effects, as did percent of class time on testing and evaluation, presumably mostly paper-and-pencil tests. For each, there was one positive value. It is possible that these variables had negative effects, with a spurious positive finding. It is also possible the effects of these formats are truly mixed, depending on their use and place in the classroom assessment environment.

The classroom assessment environment should play an important role in student achievement. But what role? Research in this area does not share the thirty-odd year tradition of research about other classroom instructional practices. This study joins a developing body of research in classroom assessment. Its unique contribution is that it is based on the LSAY. Most classroom assessment research samples classrooms from one or a few buildings or districts. Interpreting the relationships among variables across so many classrooms identified homework for math and assessment format for science as particularly important to the classroom assessment environment. The study of these relationships was limited to the variables available in the LSAY data. A further limitation is the existence of specific context, culture, and personality effects that would not be represented in this kind of model.

The general relationships discovered in these data could, however, serve as the basis for focused field studies. Alternative assessment formats in science, particularly, might be the focus of studies that included classroom time use in the investigation. The use of corrective feedback on math homework and other practice problems is another area for study. Understanding the place of these and other relationships between classroom assessment and achievement will be critical to the development of a more complete theory of classroom assessment than now exists. A theory of classroom assessment should guide current experimentation with alternative assessment and critiques of these and more traditional practices. The goal of classroom assessment is student achievement. The results of this study support the beginnings of a theory to explain how that happens.

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Table 1

Variables used in path analyses, scales, and reliabilities

VARIABLE	SCALE	Reliability*
Background Variables		
• Gender	0=M, 1=F	
• SES (composite of indexes of parent education, occupation,and household possessions)	z scores (-3 to +3)	
• Reading comprehension	0-15	.80-.86
Achievement (measured each fall, 1987-1991)		
• Mathematics (based on IRT)	0-100	.86-.95
• Science (based on IRT)	0-100	.79-.91
Classroom Assessment Environment Variables		
Student Report (from fall surveys, 1987-1991)		
• like subject	1-5, Really like to Hate**	
• teacher clarity	1-5, Very clear to Not clear at all**	
• challenge of class	1-5, Challenges a lot to Never challenges**	
• career utility	1-5, Very useful to No use**	
• text clarity	1-5, Very clear to Hard to understand**	
• difficulty	1-5, Very easy to Very difficult**	
• hours homework/week	hours	
Teacher Report (from fall surveys, 1987-1991)		
Classroom work		
• percent class time on testing/evaluation	0-100	
• written reports on experiments or systematic observations (science only)	1-5, Every day to Very rarely**	
• oral reports	1-5, Every day to Very rarely**	
• design/conduct own science projects (science only)	1-5, Every day to Very rarely**	
• written reports on outside readings	1-5, Every day to Very rarely**	
• explain reasoning to arrive at answer (years 3-4 only)	1-5, Every day to Very rarely**	
Homework		
• Hours per week assigned	hours	
• Percent of students completing hw on time	0-100	
• Percent hw corrected & returned to students	0-100	

* The reliability values are from the LSAY codebook (Miller *et al.*, 1992). Reliability for background variables was calculated for both cohorts. Reliability for achievement variables and for classroom assessment environment variables was calculated each year for both cohorts.

** Likert scales were reversed for analysis.

Table 2

Weighted sample sizes and adjusted R^2 values for stepwise regression analyses used for path analysis

	Cohort One (10th-12th grades)				Cohort Two (7th-10th grades)			
Sample year	Math		Science		Math		Science	
	n	$\hat{R}^2$	n	$\hat{R}^2$	n	$\hat{R}^2$	n	$\hat{R}^2$
1987	946	.37	813	.34	1527	.38	173	.34
1988	739	.73	585	.66	1463	.72	1256	.69
1989	118	.83	159	.68	181	.69	417	.70
1990					989	.67	429	.64

Table 3

Summary of effects on 12th grade mathematics achievement for Cohort One

Effect	Direct	Indirect	Total
Background			
Gender		-.13	-.13
SES		.08	.08
Reading		.43	.43
Prior Math Achievement			
10th grade	.48	.36	.84
11th grade	.45		.45
10th CAE			
percent class time testing		-.05	-.05
hours homework assigned		.09	.09
percent completing hw on time		.14	.14
percent homework returned		-.07	-.07
11th CAE			.00
12th CAE			
hours homework assigned	.09		.09

CAE -- Classroom Assessment Environment
hw -- homework

Table 4

Summary of effects on 10th grade mathematics achievement for Cohort Two

Effect	Direct	Indirect	Total
Background			
SES		.02	.02
Reading	.19	.38	.57
Prior Math Achievement			
7th grade	.21	.30	.51
8th grade		.22	.22
9th grade	.49		.49
7th CAE			
difficulty		.05	.05
percent class time testing		.03	.03
how often written reports		-.03	-.03
hours homework assigned		.03	.03
percent completing hw on time		.09	.09
percent homework returned		-.03	-.03
8th CAE			
percent class time testing		-.01	-.01
hours homework assigned		.01	.01
percent completing hw on time		.01	.01
percent homework returned		-.01	-.01
9th CAE			
how often written reports		-.05	-.05
percent homework returned		-.05	-.05
10th CAE			
teacher clarity	.06		.06
percent completing hw on time	.06		.06

CAE -- Classroom Assessment Environment
hw -- homework

Table 5

Summary of effects on 12th grade science achievement for Cohort One

Effect	Direct	Indirect	Total
Background			
Gender	-.11	-.17	-.28
Reading		.38	.38
Prior Science Achievement			
10th grade	.32	.38	.70
11th grade	.50		.50
10th CAE			
difficulty		.06	.06
how often oral reports		-.07	-.07
how often science projects		.06	.06
hours homework assigned		.06	.06
percent completing hw on time		.08	.08
11th CAE			
percent homework returned		-.03	-.03
12th CAE			.00

CAE -- Classroom Assessment Environment
hw -- homework

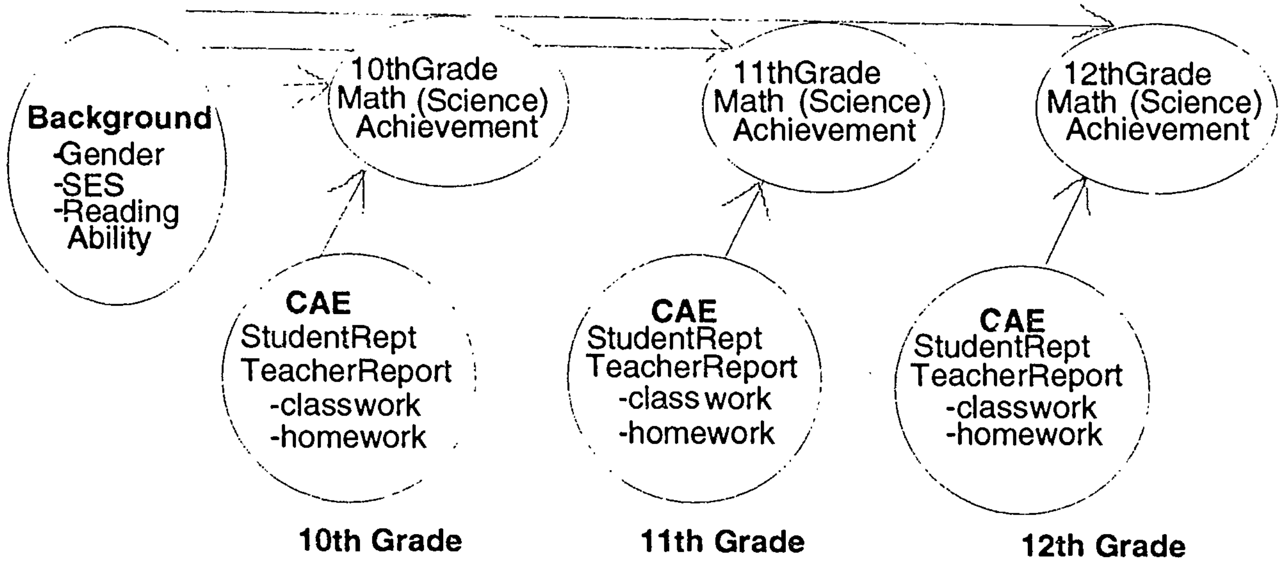
Table 6

Summary of effects on 10th grade science achievement for Cohort Two

Effect	Direct	Indirect	Total
Background			
Gender		-.12	-.12
Reading	.15	.37	.52
Prior Math Achievement			
7th grade		.51	.51
8th grade	.47	.13	.60
9th grade	.28		.28
7th CAE			
text clarity		.08	.08
how often science projects		.13	.13
how often written reports		-.08	-.08
8th CAE			
how often oral reports		-.04	-.04
how often written reports		.03	.03
9th CAE			
how often explain reasoning		-.02	-.02
10th CAE			.00

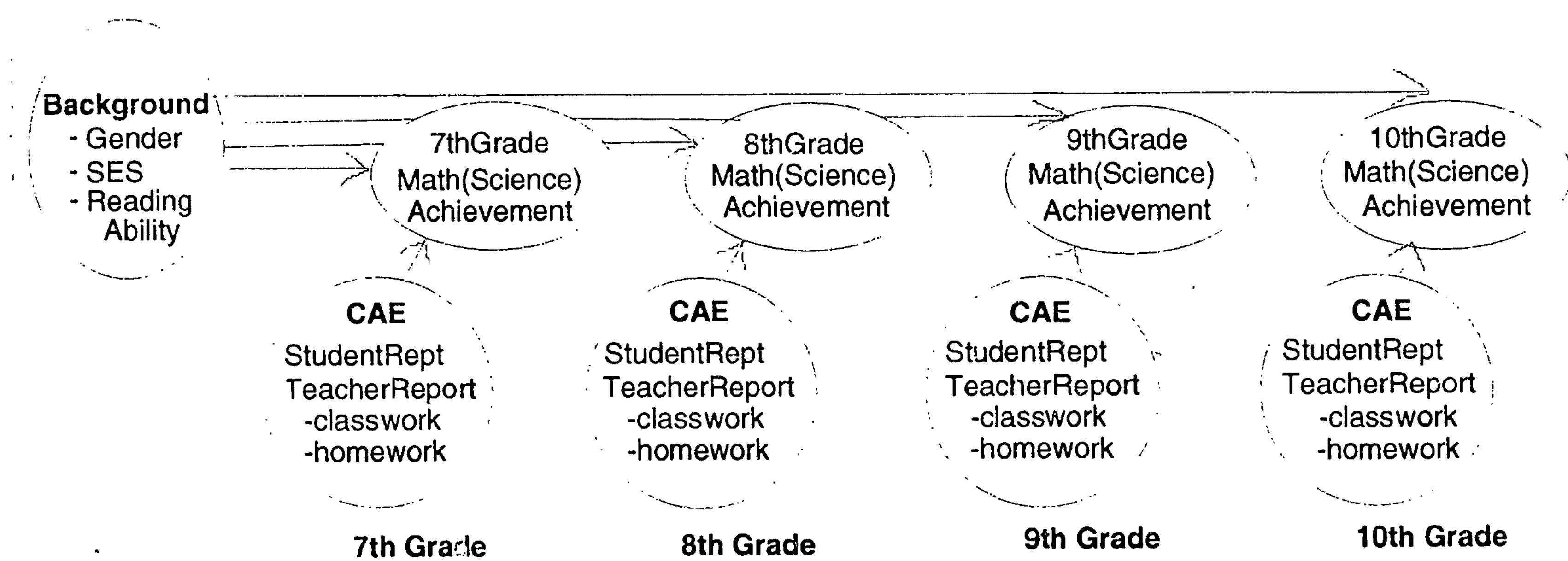
CAE -- Classroom Assessment Environment
hw -- homework

Figure 1. Model for Mathematics and Science Achievement for Cohort 1



Two separate models were tested, for Mathematics and Science classes, respectively. The Math model used Classroom Assessment Environment (CAE) variables for Math classes and Mathematics achievement scores. The Science model used CAE variables for Science classes and Science achievement scores.

Figure 2. Model for Mathematics and Science Achievement for Cohort 2



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